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Daniel T. Walters
University of Nebraska-Lincoln, dwalters1@unl.edu

C. Gossin
University of Nebraska-Lincoln

Gregory J. Teichmeier
University of Nebraska-Lincoln, gteichmeier1@unl.edu

Galen E. Erickson
University of Nebraska-Lincoln, gerickson4@unl.edu

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IMPACT OF MANURE APPLICATION ON PHOSPHORUS RUNOFF AND SOIL EROSION

D.T. Walters, C. Gossin, G. Teichmeier and G. Erickson
University of Nebraska, Lincoln, Nebraska
dwalters1@unl.edu (402) 472-1506

ABSTRACT

Phosphorus (P) losses from agricultural land is a serious environmental issue because of the impact of P on freshwater eutrophication (McDowell, et al., 2001). The movement of P from soil to surface water is impacted by P input to soil and manure management practices that impact P transport processes. Twenty-one natural runoff plots were established to monitor the effect of time and method of composted beef feedlot manure application and feed P input on net losses of bio-available P and sediment in surface runoff. Reducing feed P inputs resulted in a 33% reduction in manure P content. Runoff losses of P were reduced in direct proportion to feed P inputs. Runoff volume and sediment losses were lowest in the year s of compost application and we observed that a longer time interval between compost application date and spring runoff season resulted in increase sediment, runoff and P loss. Bray-P1 extractable soil P (0-15cm) increased from 27 ppm prior to compost application up to 400 ppm in direct proportion to manure P loading rate. Management criteria designed to assess the potential for landscape P-loading (i.e. "P-index") correctly weight winter applications as more hazardous than planting time applications. Results indicate that reduction of P input at the feedlot will have a long-term impact in reducing P loading to surface waters.

MATERIALS AND METHODS

Twenty-one natural runoff plots (0.004 ha ea.) were established on an irrigated Sharpsburg sicl (fine, smectitic, mesic Typic Argiudoll) in 1998 to monitor the effects of manure application time as well as the long term impact of reducing P finishing diets on P losses in runoff and sediment. Plots were arranged in three tiers of 7 plots each. Average slope was 6.2%. Beef feedlot manure was generated from the University of Nebraska beef research feedlot from calves fed a diet with or without supplemental P (High-P vs Low-P) and composted for a period of one year prior to land application to the runoff plots (Erickson, et al., 1999). Annual compost applications were made at a rate to meet the N needs of the maize crop (200 kg N/ha) assuming 30 % mineralization of organic N each year. Compost was applied with three method/time treatments in a randomized complete block array with 3 replications to evaluate the effect of management on P losses in runoff. A replicated control consisting of 200 kg N ha^{-1} applied as NH_4NO_3 broadcast incorporated prior to spring tillage was also included in the treatment array. Plots were disked once prior to planting so that the winter and spring incorporated treatments (SpI and W) were partially incorporated prior to planting.

Three consecutive annual applications of composted manure were made beginning in 1998 through 2000. The first winter application was made in January of 1999 and the last in January of 2001. Corn was planted @ 65,000 pl/ha in 1999-2000. Soybean was planted @ 340,000 pl/ha in 2001. No manure or fertilizer applications were made after January, 2001. A summary of treatment variables is given in Table 1. Table 2 lists the compost N and P characteristics by year. Soil samples were collected annually prior to spring compost application at 3 depths: 0-2.5 cm, 2-5 cm, and 5-15 cm, and analyzed for Bray P-1, water soluble P (WSP), and bioavailable P (BAP). Runoff collection was initiated in 1999 following natural precipitation events and analyzed in duplicate for volume, sediment concentration, and bioavailable P (BAPunf) (Sharpley 1993).

Table 1: Summary of Treatments

Treatment Name	Compost Type	Method of Application	Time of Application
H – Sp – I	High – P	Incorporated	Spring – preplant
H – Sp – S	High – P	Surface-Applied	Spring - postplant
H – W	High – P	Surface-Applied	Winter
L – Sp – I	Low – P	Incorporated	Spring - preplant
L – Sp – S	Low – P	Surface-Applied	Spring - postplant
L – W	Low – P	Surface Applied	Winter
N fertilizer	None	Incorporated	Spring – preplant

Table 2: Compost characteristics and application rates.

Compost Type	Year	Total N %	Total P %	N:P ratio	Compost Rate† Mg/ha	Applied P kg/ha
High – P	1998	0.81	0.36	2.3 : 1	83	300
	1999	0.80	0.43	1.9 : 1	83	360
	2000	0.64	0.46	1.4 : 1	103	490
						Total: 1150
Low - P	1998	0.81	0.28	2.9 : 1	83	230
	1999	0.79	0.36	2.2 : 1	83	300
	2000	0.60	0.20	3.0 : 1	111	220
						Total: 750

†Compost rate to deliver 200 kg N/ha assuming 30% mineralization rate of organic N.

RESULTS AND DISCUSSION

Animal Performance*:* Briefly, the reduction of dietary P from conventional levels improved animal P use efficiency, decreased P excretion and did not affect animal performance. Erickson et al., (1999) concluded that typical grain finishing diets (0.14% P) contain enough P for optimal gains.

Runoff, Sediment and P Losses

In this eastern Nebraska environment, runoff occurred only during the spring months (March–June) and only trace amounts of runoff were experienced in the fall. Results are shown for two distinct periods: a) compost application years (1999-2000), and b) residual year (2001) following three years of compost application.

In the years of compost application (1999-2000), time of application effect on compost weathering had a significant effect on runoff volume loss. We observed that a longer time interval between compost application date and spring runoff season resulted in a diminished effect on water retention. Runoff volume was not affected by compost type as rate of application did not differ between High-P and Low-P manures. Spring applications had the effect of decreasing runoff volume compared to winter application.(Fig.1) In the residual year (2001), when no compost was applied, runoff volume was approximately 2/3 of the no-compost control. Note that 2001 runoff volume from the 2001 winter application was lower than that from the spring 2000 application because of the difference in the time of compost weathering between these treatments. The winter application in Figure 2 was applied almost eight months after the spring application. Sediment losses in the years of application (1999-2000) were directly proportional to runoff volume. Although sediment concentrations were higher in the surface-applied treatments, decreased runoff volume reduced the total sediment load. (Fig. 1). In the residual year (2001) winter application of compost resulted in very high sediment concentration in runoff following a substantial winter runoff event when the soil surface soil was frozen. Sediment load was not impacted by compost type in 2001. (Fig. 2)

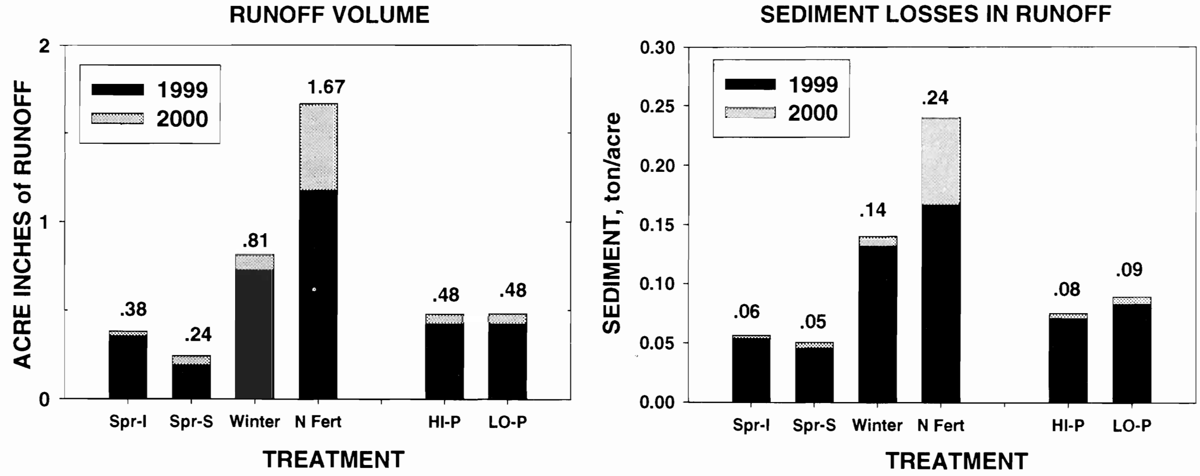

Figure 1. Annual runoff and sediment losses, by treatment, experienced in years when compost applications were made (1999-2000).

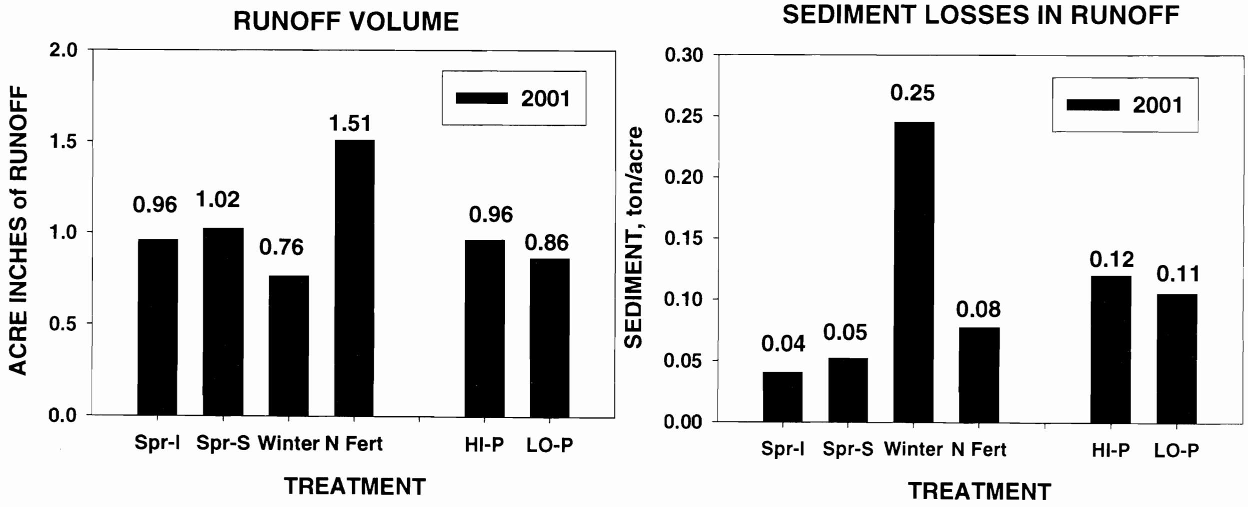

Figure 2. Annual runoff and sediment losses, by treatment, experienced in the "residual" year (2001) when no compost applications were made.

Bioavailable P (BAP) losses in runoff were proportional to P loading rates by compost type in both application and residual years of study. P loading to soil as compost was 1.5 times greater for the high-P vs the low-P manure and BAP losses were 1.5 time greater from high-P vs. low-P amended plots. More phosphorus as BAP was lost during the application years of 1999-2000 from the winter treatment compared to the spring-applied compost treatments (Fig 3). Most "P-indices" place a greater penalty on winter manure applications than those made at planting time. Our results confirm that the diminished runoff protection from winter applications because of weathering and the danger of runoff from frozen soil increases the hazard of P loss to surface water. In the "residual" year (2001) compost application no longer had the effect of reducing runoff and so BAP losses were more than double that from the control. Application time no longer had the effect of reducing BAP losses in the residual year (2001) (Fig. 4).

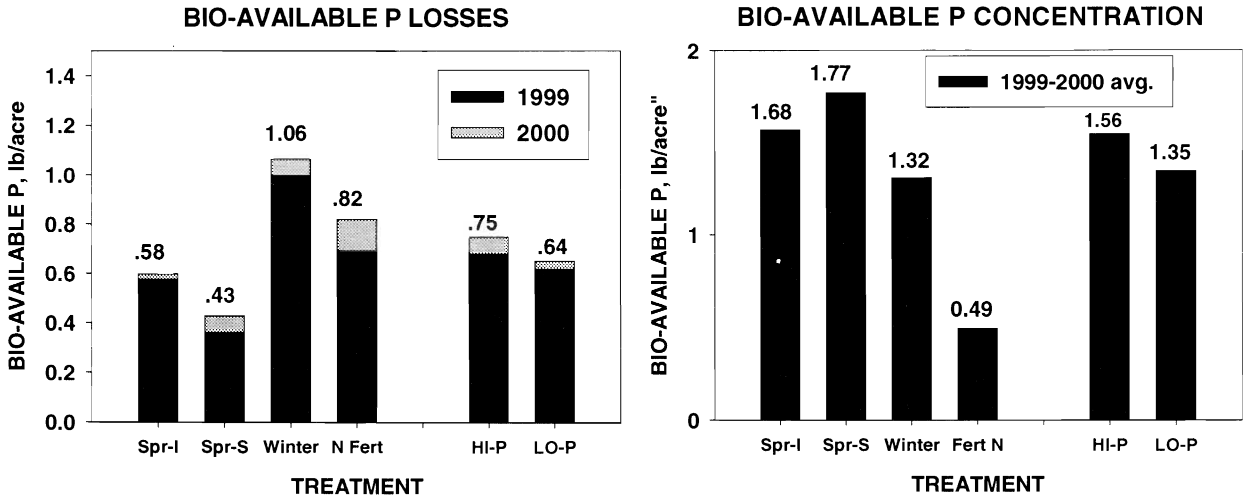

Figure 3. Annual bio-available P (BAP) losses and average BAP concentration in unfiltered runoff, by treatment, experienced in years when compost applications were made (1999-2000).

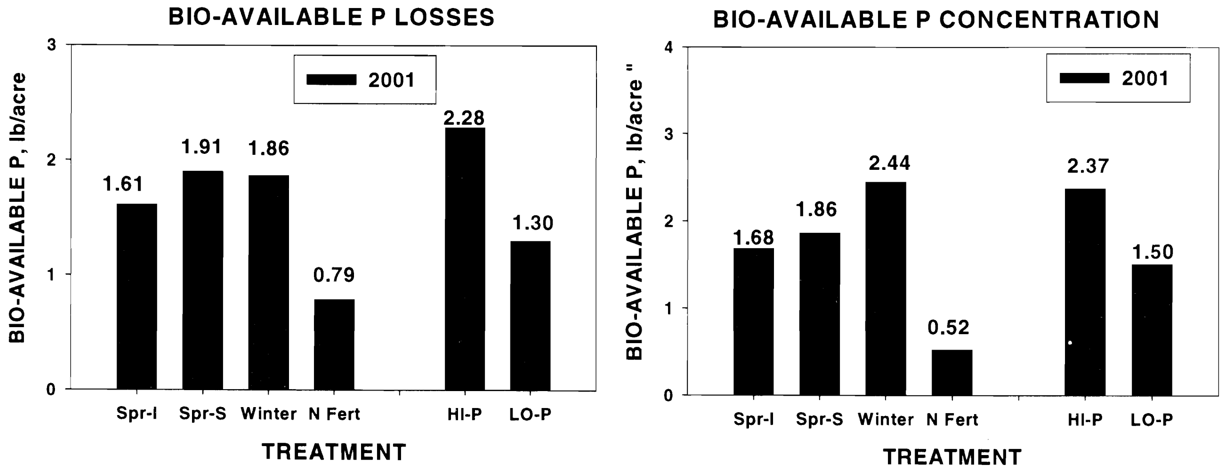

Figure 4. Annual bio-available P (BAP) losses and average BAP concentration, by treatment, experienced in the "residual" year (2001) when no compost applications were made.

Soil Test P Phosphorus levels as measured by the Bray P-1 soil test varied with depth over the period of study. Bray-P1 values (0-15 cm) increased in proportion to P loading. (Fig. 5) Bray P-1 levels under both compost types increased substantially at the 0-2.5 cm depth until 2000. After the final 2000 year compost applications, Bray P-1 level increased in the 2.5-5 cm depth at a much greater rate than in the 0-2.5 cm depth, suggesting that the soil P adsorption capacity had been reached at the soil surface resulting in some downward P movement. Bray P-1 values for the control (No Compost) plots decreased slightly over the study period (Fig 6).We examined the relationship between depth of Bray P-1 soil test and average annual BAP runoff concentration following spring soil sampling each year. There was very poor correlation between Bray-P1 soil test and BAP loss during the years of compost application (data not shown) Since P losses from runoff are primarily related to surface (0-2.5 cm) soil P, it has been suggested that the common 0-15 cm soil sampling depth is inadequate for assessment of P loss potential, especially if P is stratified. We compared the relationship between Bray-P1 soil test value and average BAP concentration in runoff in the residual year (2001). There was no significant advantage to a shallow (0-2.5 cm) sample in predicting P loss in runoff.

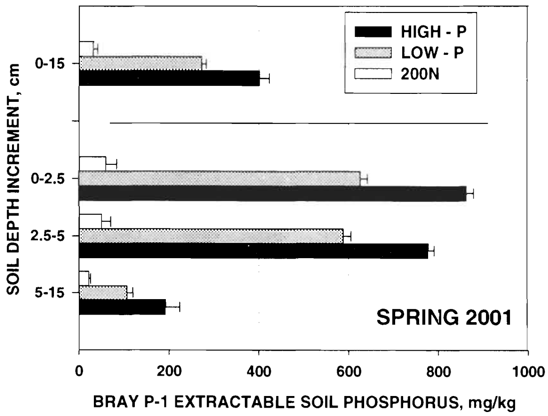

Figure 5. Bray-P1 extractable soil phosphorus in the spring of 2001 prior to planting.

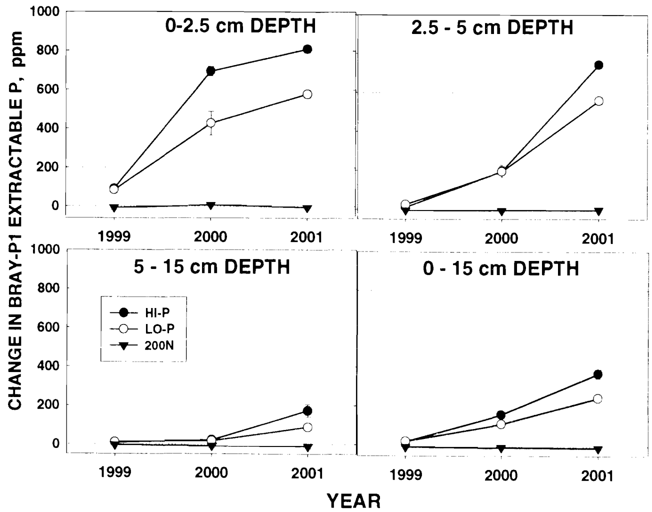

Figure 6. Change in Bray-P1 extractable soil P as a function of time, depth and P loading.

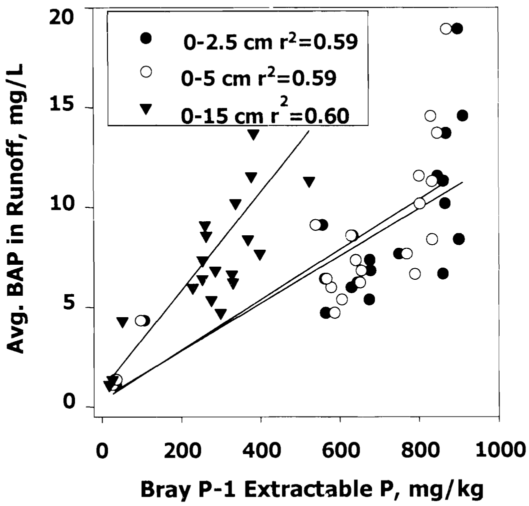

Figure 7. Correlation between 2001 Bray P-1 extractable soil P at three depth increments and average bio-available P (BAP) concentration in 2001 runoff.

CONCLUSIONS

Runoff P losses were directly proportional to phosphorus inputs in feed. A Low-P diet fed to cattle is a viable means of reducing P loading to the environment and subsequent losses in surface runoff. The timing and management of manure are also important considerations for controlling P losses in runoff in the year of application, however residual effects of timing and management are probably of little consequence. Annual compost applications resulted in the buildup of soil test P, especially in the 0-2.5 cm depth. Bray P-1 extractable P levels were affected by compost type. P movement was apparent after 3 years of compost application at rates intended to meet maize N need. Soil test P at various depths was a poor indicator of BAP concentration in runoff during the years of compost application. The correlation between STP and BAP improved once compost application was discontinued. No one depth of sampling was determined to be a better predictor of P losses in runoff than another

ACKNOWLEDGEMENTS

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